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(54) SAFETY HELMETS

SCHUTZHELM

CASQUE DE PROTECTION

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Description

The present invention relates to safety helmets, and particularly but not exclusively crash helmets for motorcyclists.

The general requirements for a safety helmet are that it should have a strong and shatterproof outer shell and an inner support or lining which spreads and cushions any sharp blow to the shell. A motorcycle crash helmet also has various special requirements, such as that it should protect the face and the back and sides of the user's head as well as the top of the skull, that it should not come off in an accident, that it should resist penetration by sharp objects, and that it should have a transparent visor.

The standard construction of crash helmet consists of a substantially spheroidal outer shell of tough plastics material, which may be made by injection moulding, wet laying up, or a similar process, and an inner lining of resilient material. The outer shell may be a glass fibre or Kevlar™ laminate, and the inner lining may be a foam material. When such a helmet is struck, the energy is dissipated and absorbed primarily by the inner lining; the outer shell is essentially rigid, and serves primarily to transmit and spread the load to the inner lining.

As shown in FR 2 336 169 (Gallet), the outer shell may be formed as a sandwich, comprising outer and inner composite layers each of high tensile strength material impregnated with resin, separated by an intermediate layer of honeycomb material. GB 717 121 (George) and FR 2 346 992 (Morin & Coignac) show similar constructions.

The main object of the present invention is to provide an improved crash helmet, though the invention extends to safety helmets generally.

Accordingly the invention provides a safety helmet comprising an outer shell formed as a sandwich, comprising outer and inner composite layers each of resin and impact-resistant material separated by an intermediate layer of resilient material, *characterized in that* the outer shell is of generally polyhedral form comprising a plurality of polygonal faces, preferably approximately in the form of part of a truncated icosahedron.

The impact-resistant material may be a cloth of Kevlar™, Dynema™, glass fibre, or carbon fibre. The resilient material may be cork or foamed or other resilient plastics material, but is preferably honeycomb material of paper or aluminium.

The invention also provides a manner of constructing such a safety helmet, comprising sequentially laying up, in or over a former, a first composite layer of resin and sheets of impact-resistant material, an intermediate layer of honeycomb material, and a second composite layer of resin and sheets of impact-resistant material.

Further features of the invention will be described with reference to an embodiment thereof in the form of a crash helmet, given by way of example and with reference to the drawings, in which:

Fig. 1 is an enlarged partial sectional view of the structure of the helmet; and

Fig. 2 is a simplified perspective view of the helmet.

The helmet is made using a mould of the appropriate shape, typically a part of a spheroid. A female (external) mould can be used; such a mould can be of, eg, 2 pieces, so that the helmet can be removed from it. However, a male (internal) mould (of, eg, 3 pieces, so that it can be removed when the helmet is made) can be used. It is easier to construct the helmet using an internal mould; however, with an external mould, a good finish to the outer surface of the helmet can readily be achieved.

The helmet is constructed in three stages - forming the first shell or membrane, forming the layer of honeycomb material, and forming the second shell or membrane. If the helmet is made using a female mould, the first shell is the outer shell and the second shell is the inner shell. Each shell is formed using resin and impact-resistant cloth such as Kevlar™ or Spectra 900™.

The shells may be formed using spreadable resin and strips of impact-resistant cloth. Convenient resins are epoxy (which is thermosetting) or phenolic resins (eg PEI - polyetherimide or PES - polyethersulphone, which are thermoplastic), and convenient impact-resistant materials are Dynema™, Kevlar™, and carbon fibres.

Layers of resin are spread, with strips of cloth being pressed into each layer, using sufficient layers to give an adequate strength. An alternative procedure for making the shells is to use strips of impact-resistant cloth pre-impregnated with resin. Around 3 layers for each shell have been found to be convenient, with successive layers being laid in different directions, to give good general strength and flexibility, since such strips are generally stronger in the weft than in the warp direction. The directions may for example be at steps of 45° for 3 layers, or 90° for 2, to give close to isotropic strength and stiffness. It is desirable for the outer shell to be thicker than the inner shell; convenient thicknesses are 1 mm for the outer membrane and 0.5 mm for the inner.

The layers of cloth for the first shell are laid and pressed into position manually, but their conformance to the inside of the mould is preferably assisted by evacuating the space outside the mould (the mould having suitable porosity and/or inserting into the mould a balloon which is inflated to press the layers against the inside of the mould.

Once the first shell has been formed, a layer of honeycomb material is inserted in it. A suitable material is Nomex™ aramid material, formed as a network of hexagonal cells, with a thickness of some 5-6 mm. Such honeycomb materials are normally highly flexible, and a sheet of suitable size may be used without cutting, by pushing it gradually into the first shell in the mould. (This will of course result in the cells being denser towards the bottom (neck) part of the helmet.) The honeycomb

material can be pressed into position by a balloon as described above.

The inner shell is then formed inside the honeycomb layer, in substantially the same way as the outer shell was formed.

The shells are then cured, to set the resin, by heating to a suitable temperature for a suitable time. This curing may be performed separately for the two shells, but can be performed as a final stage after the full structure of three layers has been formed.

The honeycomb layer should adhere to the two shells which it separates; this can conveniently be achieved by using resins and a honeycomb material which will adhere together, selecting a honeycomb material with a suitable surface coating if necessary. This adhesion may be developed during the curing process.

Fig. 1 shows diagrammatically the resulting layered structure. One shell layer is shown as formed of strips of impact-resistance material 30, 31, and 32 laid one over the other in different directions; the other shell 33 is shown complete; and the two shells are separated by a honeycomb layer.

Any helmet has a downward opening, so that it can be lowered onto the user's head. The mould is obviously made in the shape of the helmet, with a downward opening corresponding to the downward opening of the helmet. This allows the various layers or shells of the helmet structure to be inserted into the mould during the laying up of the helmet.

Crash helmets normally extend down around the user's head so that the head is almost completely enclosed, and therefore also normally have a visor opening to allow the user to see out. For the present crash helmet, the mould is preferably made to match the intended shape of the helmet without a visor opening, ie consisting of a spheroid with only the base opening which allows the entry of the user's head. The helmet is therefore laid up in the mould as a spheroid with only the base opening which allows the entry of the user's head. The visor opening is then cut out after the shell structure has been formed, either before or after curing. Edgings are then added around the edges of both the head opening and the visor opening, and glued in position to give a finished appearance and protect the exposed edges of the honeycomb material.

Hinges or other mountings will also, of course, be attached at suitable points so that a transparent visor can be mounted on the helmet.

The helmet may also be provided with an inner support or lining of webbing or other resilient material. The primary function of this inner lining is to give a comfortable fit to the user's head, though it will also provide a further cushioning and spreading effect on any sharp blow to the shell.

The helmet can of course be painted as desired; it is of course desirable to choose a resin which is not affected by the paint.

Crash helmets normally have a smoothly curved spheroidal form, and such a form may be used for the present helmet. Alternatively, however, the helmet may have a somewhat polyhedral form over at least part of its surface. More specifically, the preferred polyhedral form is based on a truncated icosahedron. (This is approximately the usual pattern of present-day footballs, though football have the polyhedral faces curved to give a close approximation to a sphere.)

Fig. 2 shows this preferred polyhedral form. The top polygon 10 of the helmet is a hexagon, which is horizontal and approximately parallel to the bottom edge 11 of the helmet. A pentagon 12 forms the foremost polygon, sloping down from the top polygon 10; this polygon forms one of a ring 13 of six polygons, alternately pentagons and hexagons, around the top polygon 10.

In a true truncated icosahedron, the ring 13 would be followed by a ring 14 of nine polygons, consisting of three pairs of hexagons separated by three individual pentagons. In the present helmet, approximately a third of this ring is missing, to form the viewing aperture 15. More precisely, the two front hexagons are almost completely missing, with only triangular portions 16 remaining, and the two front pentagons 17 adjacent to them have relatively small portions removed.

In a true truncated icosahedron, the ring 14 would be followed by a second ring 18 also of nine polygons, like the ring 14 but oppositely oriented. In the present helmet, this ring is cut off at its lower edge to form the bottom edge 11 of the helmet. More precisely, both the pentagons and the hexagons are slightly truncated, with the hexagons having removed from them triangular portions slightly larger than the portions 16 remaining of the front two hexagons of the ring 13.

In addition, the shape of this ring 13 departs substantially from the true truncated icosahedron at the front of the helmet. The front pentagon of this ring in a true truncated icosahedron is entirely missing, and instead, the two hexagons 19 adjacent to it are curved to merge in a smooth curve around the lower front of the helmet.

It will be realized that the meeting lines of the various polygons are in fact slightly rounded, rather than sharp as shown; also, the vertexes of where the polygons meet are rounded, as indicated. Further, some or all of the polygons themselves, such as those around the bottom edge 11 of the helmet, are slightly curved; in particular, the polygons 22 are curved to slightly spread the outline of the bottom edge 11 into a relatively smoothly curved surface.

A helmet of this shape is constructed using a mould of corresponding shape. After the helmet has been shaped, its edges are preferably finished by fitting strips of U-shaped material, as shown at 25 and 26 and piercing a pair of holes 27 as shown for a transparent visor to be hinged to the helmet.

It will be realized that with the polyhedral form of the helmet, the shape can be based on any suitable polyhe-

dron, ie any shape which is a reasonable approximation to a sphere.

The polyhedral shape of a helmet so constructed, and the material of such a helmet, both provide an improved resilience and impact resistance to both sharp and blunt objects. The flat sections of the polyhedral shape allow localized plate deformation and bending to occur with acceptable design deformation limits, and the composite construction contains external deformations of the helmet within the shell structure without them penetrating through.

With the present construction, the outer membrane serves to transmit and spread the load of any impact to the honeycomb. The inner membrane provides a relatively rigid support for the honeycomb, which acts as the main energy absorbing and dissipating element. The outer membrane is preferably thicker than the inner membrane (eg 3 plies for the outer membrane and 2 for the inner), as the outer membrane has to withstand greater localized loads than the inner membrane. Compared with a conventional helmet, the present construction can achieve a 30% weight saving in combination with a 35% improvement in energy absorption of some 150 J on the first impact and some 110 J on the second impact (tested to the Snell SA90 specification).

For applications other than crash helmets, the various parameters may need to be changed appropriately. Thus for ballistic protection, the shells may be constructed of a Dynema™/glass hybrid composite using around 12 plies in all. This yields a shell weight of around 5 kg m^{-2}; the shell has a penetration resistance of V50, measured using 0.22 calibre 170 gr fragment at some 700 m s^{-1}.

Claims

1. A safety helmet comprising an outer shell formed as a sandwich, comprising outer (33) and inner (30-32) composite layers each of resin and impact-resistant material separated by an intermediate layer (34) of resilient material, *characterized in that* the outer shell is of generally polyhedral form comprising a plurality of polygonal faces.

2. A safety helmet according to claim 1 *characterized in that* the polygonal faces are pentagons and hexagons forming part of a truncated icosahedron.

3. A safety helmet according to either previous claim *characterized in that* the impact-resistant material is a cloth of high tensile strength fibre.

4. A safety helmet according to claim 3 *characterized in that* the fibre is Kevlar™, Dynema™, glass fibre, or carbon fibre.

5. A safety helmet according to any previous claim *characterized in that* the resilient material is honeycomb material of paper or aluminium.

6. A safety helmet according to any of claims 1 to 5 *characterized in that* the resilient material is cork or foamed or other resilient plastics material.

Patentansprüche

1. Schutzhelm mit einer äußeren, als Schichtkörper geformten Schale, die äußere (33) und innere (30-32) zusammengesetzte Schichten jeweils aus Harz und schlagfestem Material umfaßt, die durch eine Zwischenschicht (34) aus elastischem Material getrennt sind,
dadurch gekennzeichnet, daß die äußere Schale eine allgemein polyedrische Form aufweist, die eine Vielzahl von vieleckigen Flächen umfaßt.

2. Sichterheitshelm nach Anspruch 1,
dadurch gekennzeichnet, daß die vieleckigen Flächen Fünfecke und Sechsecke sind, die einen Teil eines abgestumpften Ikosaeders bilden.

3. Schutzhelm nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet, daß das schlagfeste Material ein Gewebe aus einer Faser mit hoher Zugfestigkeit ist.

4. Schutzhelm nach Anspruch 3,
dadurch gekennzeichnet, daß die Faser Kevlar™, Dynema™, Glasfaser oder Kohlenstoffaser ist.

5. Sicherhreitshelm nach einem der vorhergehenden Ansprüche,
dadurch gekennzeochnet, daß das elastische Material ein wabenförmiges Material aus Papier oder Aluminium ist.

6. Schutzhelm nach einem der Ansprüche 1 - 5,
dadurch gekennzeichnet, daß das elastische Material Kork oder geschäumtes oder anderes elastisches Kunststoffmaterial ist.

Revendications

1. Casque de protection comprenant une coque externe formée en sandwich, comprenant des couches composites externe (33) et internes (30, 32), chacune des couches étant en résine et en matériau résistant aux chocs, séparées par une couche intermédiaire (34) en matériau élastique, caractérisé en ce que la coque externe est en forme générale de polyèdre comprenant une pluralité de faces polygonales.

2. Casque de protection selon la revendication 1, caractérisé en ce que les faces polygonales sont

- des pentagones et des hexagones formant une partie d'un icosaèdre tronqué.

3. Casque de protection selon l'une quelconque des revendications précédentes, caractérisé en ce que le matériau résistant aux chocs est un tissu en fibre à haute résistance.

4. Casque de protection selon la revendication 3, caractérisé en ce que la fibre est du Kevlar (marque déposée), du Dynema (marque déposée), une fibre de verre, ou une fibre de carbone.

5. Casque de protection selon l'une quelconque des revendications précédente, caractérisé en ce que le matériau élastique est un matériau en nid d'abeilles de papier ou d'aluminium.

6. Casque de protection selon l'une quelconques des revendications 1 à 5 caractérisé en ce que le matériau élastique est du liège ou de la mousse ou un autre matériau plastique élastique.

Fig. 1

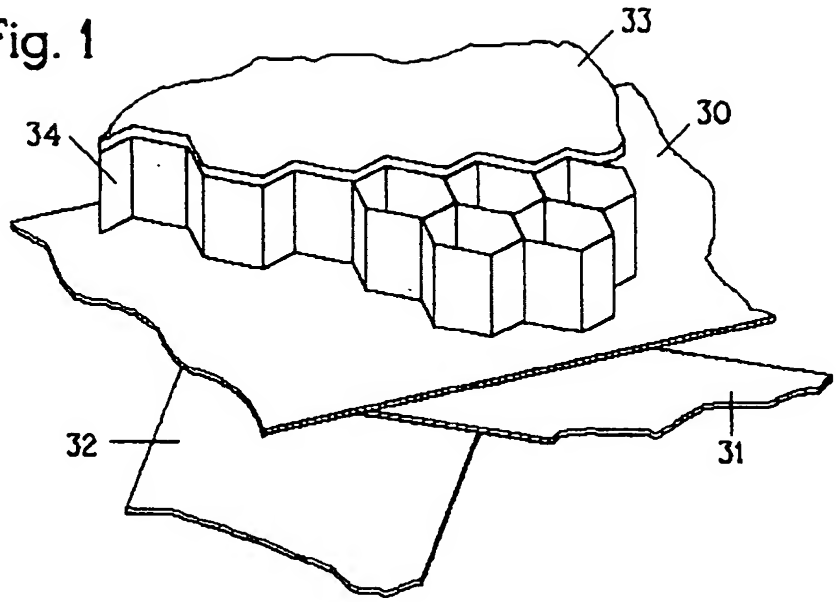
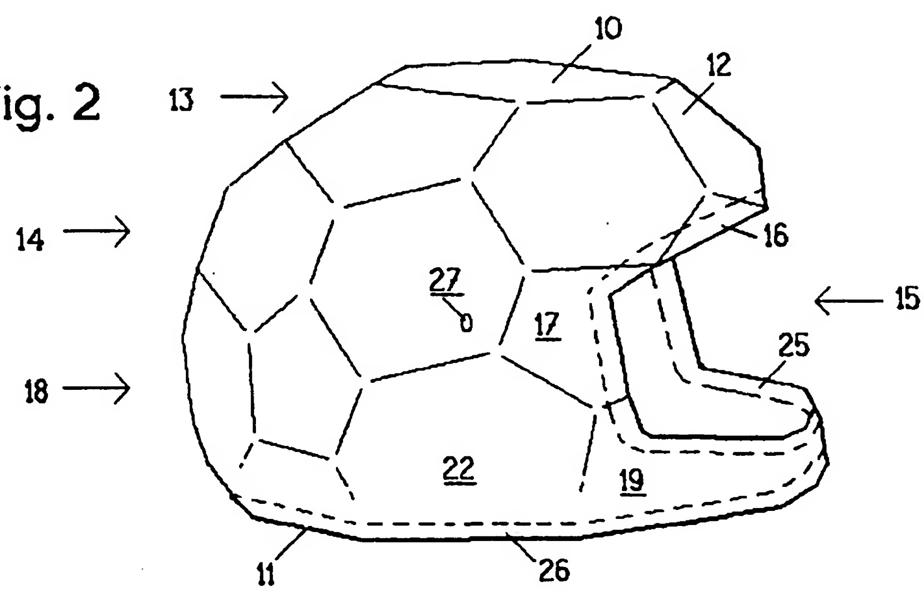


Fig. 2



The present invention rapporteà a helmet, particularly but not exclusively intended for the utili- sporting sation and primarily formed, in a known way in oneself, by an external rigid structure and an interior stuffing. The helmets of the caused kind are well known and largely used, and their realization is subjected to national and international payments pre cis which imposes the strength properties, party culièrement of their external rigid structure, with the shocks and the perforations, payments which naturally have the precise goal to safeguard the integrity of the users as much as possible of the aforesaid helmets in the case of an accident. The need for satisfying the requirements of these payments, carries to the realization of helmets of which the external rigid structures must have uneepaissor relatively élevéeet consequently a weight and a encom- brement remarkable. This obstruction is made even larger because of the need for having a thickness élevéedu stuffing for purposes to improve the penetration resistance of the whole helmet with an aim satis- of making with the existing payments. The known helmets and in the trade until today are primarily carried out by slackness lage with injection of synthetic resins, in particular resins ABS or preferably polycarbonates. Alternati- vement, they can be forms on resin-fibre moulds of glass. This last product is more expensive but of meil- leure quality thanks to a slightly higher resistance and especially to a shorter "ageing" of the resin glass fibre. However, all the caused helmets present the aforementioned disadvantages, i.e. an excessive weight, an obstruction high (and consequently a larger resistance aéro- dynamic) and a "ageing" (i.e. a degradation of the physical characteristics of the resin) more or less fast and remarkable. However, the goal of this invention is now to carry out a helmet of the kind and for the caused uses which has a conformation and a new and improved structure, able to assign with the external rigid structure of the aforesaid helmet and consequently with all the helmet, a larger resistance structural to parity of weight or preferably a weight beautiful blow lower with parity of structural resistance, with a better strength property to the perforation, making it possible to reduce interior stuffing and by consé- quent to carry out a smaller helmet, while respecting the aforementioned existing payments. To conclude, it is possible according to the invention to obtain a helmet much lighter and at the same time smaller and consequently of smaller obstruction and aerodynamic resistance. Primarily that is carried out by a rigid structure external of the helmet, which presents a conformation at sandwich with a central part formed of a skeleton having a plurality of opened cells, part of lining and part of coating external solidarized with the central part. It is particularly suitable that the central part is carried out by an element preformed in a matter plas- tick with cells laid out with honeycomb, while the parts of coating

extending on surfaces perpen- diculaires with the partition walls from the cells are convenablement formed each one by one or more layers of impregnated fabric, preferably preimpregnated with époxides or polyesters. To improve even more resistance of the helmet, in particular the penetration resistance, only with one small increase in the total weight, it is possible to fill the cells, during the process of production of the helmet, with microsphères out of glass which are hollow inside. The invention will be now described more in detail while referring to the shape of realization illustrated as an example in the annexed drawing, in which: figure 1 is a sight in matic prospect sché- components for the rigid structure external of a helmet according to the invention; figure 2 is a partial sight, with a part out of cut, of a helmet carried out by means of the struc- rigid ture of figure 1. In the drawing a helmet 10 is illustrated, which introduces primarily to an external rigid structure pro slipped by 12 and one interior stuffing 14 co-operator with the external rigid structure to assign with the whole of the helmet the desired strength properties. To achieve the aforesaid goals the external structure presents a conformation at sandwich, as one can see it figure 1. This structure presents a central part 16 formed by very thin a plastic skeleton, equipped with a plurality of cells 18 opened at the two ends and preferably laid out with honeycomb. This central part is laid out between parts of coating respectively outside 20 and inside 22 of the rigid structure of the helmet, parts which are in their turn formed each one by one or more layers of fabric preimpregnated with resins, preferably époxides or poly- esters, the aforementioned coatings extending on surfaces per- pendiculaires with the partition walls from the cells and closing however these last at the ends so as to form a very light rigid structure for the presence of the opened cells, but at the same time extremely resistant either to the shocks or with the perforations, particularly in the direc- tion perpendicular to the coatings 20 and 22. The helmet is primarily carried out with the technique of moulding like that of the achievements out of resin-fibre of glass, with the appli- cation of the lining the 22, assembly following of by tie central to honeycomb, preferably preformed and finally the application of the coating external 20 before the heat treatment which produces the final and stable solidarisation components of it structure with sandwich, in impar- so much aisni with the aforementioned structure desired rigidity. 4 2 561877 According to the invention it is possible particularly to improve the penetration resistance of the helmet with a small increase in the weight by filling the cavities of cells 18 with microsphères hollow out of glass. These microspheres, which are applied during the process of production of the helmet, is well-known in oneself (for example those under the name of "Glass Bubbles" and produced by the company 3M Company of St Paul, Minnesota - the USA) and is available in the trade. Lesmicrosphères

recommended have a diameter of approximately 60 microns and a unit weight from approximately 0, 15 g/cm3. However, they improve resistance of the helmet with a total increase in weight about some tens of grams. One thus obtains a helmet having the above-mentioned ristic caracté-, which can equipped with a rembour- rage thickness reduced compared to those of the sic helmets clas-. Claims (French) CLAIMS 1) Casque, particularly intended for sporting uses, characterized in that it presents a rigid structure external with sandwich, with a part cen- trale formed by a skeleton having a plurality of opened cells, part of coating external and part of lining solidarized with part cen- trale. 2) Casque according to claim 1, characterized in that its central part is formed by an element préfor- mé with cells laid out with honeycomb. 3) Casque according to the claim 1 or 2, characterized in that the parts of coating extend on surfaces perpendicular to the partition walls from the cells. 4) Casque according to claim 1, 2 or 3, characterized in that the preformed element has a skeleton for- mant the partition walls between the cells in a my plastic tière. 5) Casque according to one of the claims pre cédentes, characterized in that the parts of coating are formed each one by one or more layers of fabric impregnated with resins. 6) Casque according to claim 4, carac- terized in what the resins of impregnation are épo- xides or polyesters. 7) Casque according to one of the claims pre cédentes, characterized in that the interior space of the concealment lules is filled with microsphères hollow out of glass. 8) Casque according to claim 7, carac- terized in what the microsphères have a diameter of approximately microns and a unit weight of approximately 0,15 g/cm3. 9) Casque according to at least one of the revendi- cations the preceding ones, characterized in that it presents a conformation and mutual provision of parts, as those which were described and illustrated.